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BY

J. EWING MEARS, M.D.,

PROFESSOR OF ANATOMY AND CLINICAL SURGERY IN THE PENNSYLVANIA COLLEGE OF DENTAL SURGERY; SURGEON TO ST. MARY'S HOSPITAL, PHILADELPHIA, ETC.

Extracted from the
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PHOSPHORUS-NECROSIS OF THE JAWS.

THE earliest observations made with regard to the occurrence of phosphorus-necrosis of the jaws were those of Lorinser, of Vienna, who published a paper upon the subject in 1845, recording cases which occurred as early as 1839; Heyfelder, of Erlangen, and Strohl, of Strasburg, shortly after reported cases and confirmed the observations made by Lorinser. In 1846 Dr. Wilks, of London, published a paper upon the subject in *Guy's Hospital Reports.* In 1847 an exhaustive paper was published by Professors Von Bibra and Geist, of Nuremburg, which will be alluded to hereafter. In 1850 Mr. John Simon, F.R.S., delivered a clinical lecture at St. Thomas's Hospital, London, on diseases of the lower jaw produced by phosphorus fumes, illustrated by the report of two cases at that time in the Hospital. Other cases were reported, by both English and Continental surgeons, between this period and 1862–5.

Soon after the report of the cases occurring in Germany the attention of the authorities was attracted to the subject, and stringent regulations were made with regard to the adoption of preventative measures in the match manufactories of that country. In 1863 Mr. Simon made a report to the Privy Council of England with regard to the prevention of the disease. His report contained the results of the careful investigations made by Dr. Bristowe upon the subject. In 1867 Mr. Christopher Heath, in the Jacksonian Prize Essay of the Royal College of Surgeons of England, gave a full account of what was known upon the subject up to that date. In this country Dr. James R. Wood, of New York, was the first to give an account of the

disease, accompanied by the history of a case in which he removed the entire inferior maxilla. Subsequently cases were reported in which the entire lower jaw, or portions of it, were removed by Drs. Wm. Hunt and C. S. Boker, of Philadelphia, and one notable case by Dr. J. C. Huchison, of Brooklyn, in which the entire upper jaw, with the malar bone, was excised.

The text-books on surgery contain more or less full accounts of the disease; those of Profs. Gross and Agnew treat the subject at some length.

In order that information may be imparted with regard to the manner in which necrosis of the jaws is developed in connection with the manufacture of matches, it may be of interest to detail briefly the process of manufacture. The essential parts of a match are the stick, the purpose of which is to hold the flame for a sufficient length of time, and the chemical composition which is fixed upon the end, and which, by friction, ignites the stick. The stick, in order that it may take fire readily, is charged, in the common sulphur match, with sulphur, and in the finer quality of parlor match, with paraffin. The chemical composition, which tips the stick, and by friction ignites it, consists in the finer quality of match of phosphorus and chlorate of potassium, inflammable materials, with particles of ground flint to assist friction, a coloring agent, and the best quality of Irish glue to give the mixture body and adhesive properties. The tipping of the stick by the chemical composition is accomplished by dipping the ends in a warm solution of the composition, placed in shallow pans, and maintained at the proper temperature by a steam-bath. From these dipping pans fumes constantly rise into the faces of the workmen or dippers. Both ends of the match sticks are dipped, and after being allowed to dry sufficiently to permit handling, which is accomplished in four to six hours, the sticks are passed through the cutting machines and divided. In passing through the cutting machines the friction is often sufficient to cause ignition of large bundles of matches, the fumes from which envelop the cutters and keep them almost constantly surrounded by the vapor from burning tips. From the cutting machines the matches go to the pack-

ing-rooms, where they are assorted and packed, this process requiring the handling of the tips, not yet thoroughly dry, and from which vapor is constantly emitted. In addition, ignition of the matches frequently occurs, filling the packing-rooms with the fumes from the burning matches, and which the employés inhale. The stages of the process are, therefore, charging the stick with sulphur or paraffin, dipping the ends into the chemical composition, cutting the dipped sticks, and finally packing in boxes. No danger manifestly attends the process in the first stage, as neither sulphur nor paraffin is capable of producing the effects observed in necrosis of the jaws as it occurs in the employés in match factories. In the dipping process the fumes arising from the composition in heated solution are inhaled by the employés, while the material adheres more or less to the hands in the manipulation which is necessary. In the cutting of the sticks handling of the moist tipped ends occurs, with the inhalation of the fumes constantly emitted from them and from the masses of matches continuously ignited by friction. The packing requires the constant handling of the matches, and, as a result, the hands of the employés are coated with the composition so as to appear luminous in the dark, and the ever-recurring ignition of bundles of matches fills the rooms with the vapor, enveloping the work-people in an atmosphere charged with the burning composition.

In match factories the employés consist largely of females, the work being of such light character as to require but little physical strength. The ages vary from twelve to twenty, the former being the time of life at which they usually enter the service. Men are employed to work the dipping machines, and a few boys are usually employed in general work.

The effect of the nature of the work upon the employés varies in different individuals. Some engaging service are compelled to abandon work in a few days, others in a few weeks or months, and again some continue in the work for years; one notable instance is that of a woman coming under my care who had worked for twenty-six years in a factory, and was at the expiration of that time attacked with necrosis. In many there is observed a gradual deterioration of physical condition as manifested in loss of

flesh and general vigor. Necrosis of the jaws occurs in those who have been employed for a period of years in the factories, usually not until four to six years have elapsed.

The physiological effects of the phosphorus vapor are stated by authors to be irritation of the mucous membrane of the eye and of the air-passages, while in medicinal doses, taken into the stomach, the action of the heart is increased, the temperature is somewhat elevated, mental activity and muscular power are augmented, aphrodisiac effects are experienced, the urine and perspiration are freely excreted, and, in females, the menstrual flow is increased.

In toxic doses violent gastro-intestinal disturbances are caused, the mucous membrane being attacked with great energy. Severe epigastric pain, with vomiting and diarrhœa, supervenes, and in addition to the physiological effect of the agent there is also evidence of the action of a corrosive poison. Phosphorus taken into the stomach passes into the blood unchanged, and if in sufficient quantity causes rapid destruction of the red blood-globules, prevents the reaction of the fibrinogen on the fibrino-plastic substance, and thus originates an acute hemorrhagic diathesis. Transudation of blood takes place from all of the mucous surfaces. According to Wegner, the hemorrhages are due to fatty degeneration of the arterial walls. This degeneration, according to other observers, extends to the stomach, liver, heart, and later to the voluntary and involuntary muscular systems.

I have had the opportunity of examining a large number of employés in match factories and of studying the effects of phosphorus upon them. In sixteen cases I have treated the toxic effects of phosphorus as it appeared in different stages of development upon the system, and I have been interested in observing to what extent toxic symptoms could be traced and defined. Of these cases the majority has been among those who are engaged in the packing room, where the handling of the matches occurs; but one was a dipper and four were cutters.

Of the symptoms described as giving evidence of physiological or toxicological effects, very few have been noted as prominent in the cases under my observation. Beyond instances

of conjunctivitis and bronchial irritation, I have not been able to elicit definite information as to any marked effect upon the membrane of the general mucous tracts. Constipation rather than diarrhœa has been the condition which existed. Examination of both male and female employés has not revealed any history of aphrodisiac effects, and in the latter, increase in the menstrual flow has not been noted to any extent. The most marked toxic symptom observed has been the occurrence of hemorrhagic transudations from the gums, and this symptom is frequently noted among the employés. Pain over the region of the liver, sick headache, nausea, and muscular debility, are symptoms described by many, while well-defined icterus has not been observed in any case. I have been informed of three fatal cases in which the immediate cause of death was phthisis, occurring some time subsequent to operations for the relief of necrosis of the jaw.

It is evident from the absence of symptoms of acute poisoning that the invasion of the system by the poison is slow, establishing a chronic toxic condition which awaits some exciting cause to make itself manifest. Accepting as parts of the pathological processes which follow toxic effects, disintegration of the red blood-corpuscles, and fatty degeneration of the arterial walls, we find in the highly vascular periosteum a membrane most liable to exhibit the effects of these morbid changes. Owing to the weakened condition of the arterial walls consequent upon the state of fatty degeneration present, the vascular tension is wholly or in great part lost, and the tissue, while surcharged with blood, is in a state of innutrition, owing to the impoverished condition of the blood—so that I have observed in cases free hemorrhages taking place from gums blanched and apparently bloodless. This condition is most favorable for the development of inflammation, and this process follows promptly upon the appearance of the exciting cause.

In 1847 Professors Von Bibra and Geist, of Nuremberg, published a valuable monograph upon the subject of phosphorus-necrosis, containing a very complete and clear summary of all that had been written previously upon the subject, and also the

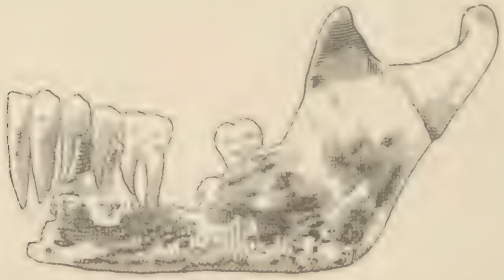
results of their very careful investigations. The conclusions arrived at were, among others, that phosphorus was the poisonous agent, and that the effects were entirely local. These statements were regarded as proven by the experiments upon rabbits submitted to the influence of phosphorus vapor. In these animals the characteristic disease could only be produced, according to the report, after laceration of the periosteum of the jaw and exposure to the vapor. As the result of these experiments the deduction was made that the agent acts only when it can come in direct contact with the periosteum, and that those employés in match manufactories who are free from carious teeth can pursue the occupation with impunity. They suffer neither locally nor constitutionally. The vapor appears to be incapable of producing any general cachexia.

While the observations which I have made agree, in general, with the conclusions stated above, it is my belief that the statement made with regard to the local effects and the introduction of the poison through carious teeth should be received with some modification. I have examined a number of employés who have had carious teeth and were yet free from the disease, and have continued to work in the factories exposed to the phosphorus vapor; also those who have had teeth extracted and have returned immediately to work in the factory and have not suffered from necrosis. A number who have suffered from the disease have given, as one of the symptoms which first attracted their attention and caused alarm, the sensation of a protrusion of a number of the sound teeth, or, as expressed by them, an elongation of their teeth—this condition would occur, and then disappear, being the result apparently of an accession of cold. In one case the teeth, on two occasions, became quite loose and the gums much swollen and very sensitive. This condition of protrusion of the teeth from the alveoli indicated an inflammation of the peri-dental membrane, a structure which is continuous with the periosteum, and which lines the walls of the alveoli and surrounds the root of the teeth. In all of the patients whom I have been able to examine in the early stages of the disease, I have found an accumulation of tartar around

the necks of the teeth; in some this tartar has existed in large plates extending beneath the gum and covering the bodies of several teeth to the crown. This accumulation is a source of constant irritation, and being lodged at the point at which the periosteum turns into the alveoli, gives rise readily to irritation of the peri-alveolar and peri-dental membrane; assuming the correctness of the statement as to the pathological condition which the periosteum acquires as a result of a chronic toxic condition, we find in the carious tooth or in the accumulation of tartar a source of irritation which is competent, under favorable conditions, to develop inflammation. It is not my belief that the poison impresses the membrane *primarily* through the carious tooth, as stated by Profs. Von Bibra and Giest, or the peri-dental membrane laid bare by the accumulation of tartar around the neck of the teeth which may have caused a recession of the mucous membrane and slight absorption of the alveolar process, but that these conditions, *per se*, under the influence of some exciting cause, as cold, etc., light up in the periosteum, already in a morbid condition, produced by constitutional impression of the poison, an inflammation, which, if not arrested, results in necrosis. The pre-existing condition, it seems to me, is therefore a morbid state of the periosteum, which under an exciting cause readily inflames; the exciting causes are found in the teeth; a carious tooth, with the pulp exposed, which structure, by some of its tissues, is continuous with the peri-dental and peri-alveolar membrane, and tartar accumulations may give rise to an irritated and sensitive condition of the borders of the reflected periosteum. It is a matter of observation that the periostitis which develops in connection with other causes, with the exception, possibly, of syphilis and mercurial poisoning, is, in many cases, of a local character, whereas that which precedes prosphorus-necrosis is, as a rule, general, passing rapidly to involvement of the entire bone, unless interfered with. In this, as in some other respects, it resembles syphilitic periostitis. In the tertiary form of syphilis the periosteum of the jaws is very prone to inflame under the irritation of carious teeth or the violence inflicted in the efforts at extraction. In the cases of phosphorus-necrosis coming under

my care, in the advanced stages of the disease, the uniform statement by the patient has been to the effect that, suffering pain in a carious tooth or in a sound tooth, a visit was made to the dentist and extraction was performed. In a day or two the jaw began to swell, and following that a discharge appeared from the point of extraction, the history of the beginning of suppurative periostitis caused by the efforts at extraction. In some cases I have found portions of the teeth remaining and the alveolar process greatly broken. The results of the experiments obtained by Profs. Von Bibra and Giest upon rabbits are not at variance with the views expressed above, since, according to the statements made, the animals in some instances were exposed for a period of time to the fumes of phosphorus before the periosteum was removed and the bone denuded, and it is quite reasonable to believe that being easily impressed by the poison, a morbid condition of the periosteum had supervened so that the laceration of the membrane was sufficient to excite the inflammation. In those animals in which the lower jaw was fractured, laying bare the roots of the molar teeth previous to the exposure to phosphorus vapor, there were evidences, on post-mortem examination, of serious constitutional, as well as local, effects.

Fig. 1.



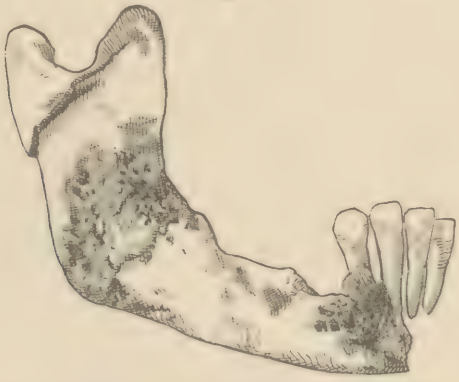
Condyloid process covered with new bone formation.

The specific inflammation excited in the periosteum progresses rapidly, and results, in cases of the lower jaw, in the formation of laminated layers of new bone, which envelop the jaw, stopping at the borders of the alveolar process in front and

behind, but completely surrounding the angle, ramus, and both processes.

In a number of the specimens removed by me the new bone formation had encroached upon the articulating surface of the condyloid process (Figs. 1 and 2), and in one instance completely

Fig. 2.



Condyloid process covered with new bone formation.

covered both condyloid and coronoid processes (Fig. 3). An interesting result has occurred in one case under my observa-

Fig. 3.

Condyloid and coronoid processes covered with new bone formation.

tion in which the patient refused operative interference; the necrotic action had continued for six years, and the layers of new bone had united over the position of the alveolar border,

thus entirely inclosing the sequestrum, which is slowly disappearing, the discharge escaping externally by a sinus at the angle of the jaw. The muscles attach themselves to the periosteum covering the new bone, and are lifted off, as it were, with that membrane.

In some of the specimens in my collection portions of the new bone have exhibited the pumice-like appearance described as characteristic of this specific form of inflammation (Fig. 4); this

Fig. 4.

Pumice-like deposit on body and part of ramus.

appearance has also been observed upon the surface of the sequestrum. In other instances it has been absent, in this respect confirming the opinion which has been expressed that it is not present in every case, and therefore not pathognomonic.

Profs. Von Bibra and Geist have made careful examinations microscopically and chemically of the bone deposited by the periosteum in these cases. It is described "as lamellated, with large Haversian canals, not running *parallel* to the general direction of the bone, but placed at right angles—the lacunæ are rounded off; the proportions of organic and inorganic matter vary, the average being in eight specimens—organic matter 32.4, inorganic 6.76."

Mr. John Adams, in a clinical lecture, published in the *Medical Times and Gazette*, July 5, 1852, states that these conditions are not observed in bone formed as the result of common inflammation.

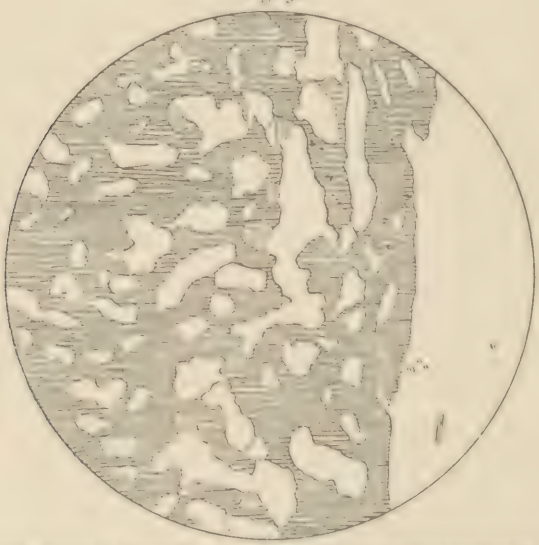
Mr. Thomas Smith, in the *St. Bartholomew's Hospital Reports*, vol. i., reports a case in which he removed the sequestrum of the entire lower jaw, the newly formed jaw showing on microscopic examination "all degrees of development, from a finely fibro-nuclear matrix up to perfect bone. The bone differs from ordinary compact bone in being excessively vascular, the Haversian canals being very large, near together, freely anastomosing, and here and there in their walls presenting fusiform and pouch-like dilatations, in fact resembling, in their outlines, veins slightly varicose. The bone is thickly studded with lacunæ, and these are peculiar in being very large in their cavities, less uniform in their general outline, and containing fewer canaliculi than is usual in well-formed bone. In the newest parts of the bone the lacunæ are merely irregularly-formed cavities without distinct canaliculi." These appearances correspond largely with those observed in general in new-bone formations, and do not seem to me to be sufficiently distinctive to confine their description to formations occurring as the result of phosphorus-necrosis.

I append the report of Dr. Morris Longstreth upon a specimen of new bone formation taken from one of the cases under my care, and submitted to him for examination.

In the specimen of periosteal outgrowth from the case of phosphorus-necrosis of the lower jaw, two sets of sections have been made; one, vertically to the surface, including the entire thickness of the growth; the other horizontally. The sections (Figs. 5 and 6) show as their striking features the enormous size of the canalization system and the slenderness of the bone-trabeculæ. In the horizontal sections the canals appear of a greater diameter than in the vertical sections. The thickness of the bone-trabeculæ appears about the same in whatever direction the tissue is cut. The inference to be drawn from this arrangement is that the canals, being connected with the vascular system, either of the jaw bone, on the one hand, or, on the other, with that of the periosteum, have their extension chiefly in the vertical axis. This mode of distribution is evident from a naked-eye examination of the specimen, and is especially evident on its under surface; the upper surface is denser and more compact. It would give a wrong impression to assert

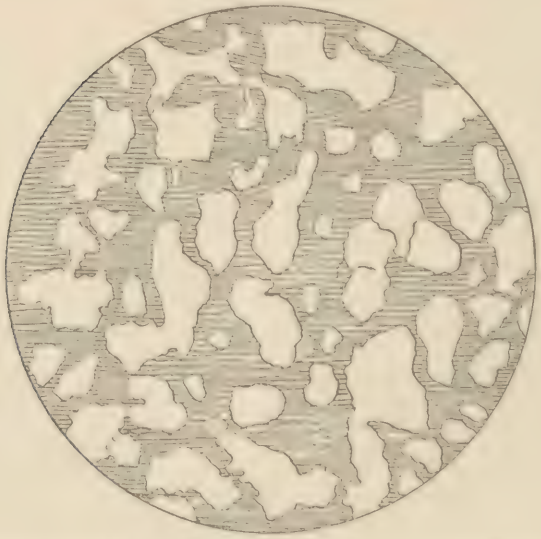
that the canalization is wholly in the direction of the vertical axis. The ramification of the canals proceeds in every direction through

Fig. 5.



Vertical section of periosteal outgrowth from phosphorus-necrosis of jaw.

Fig. 6.



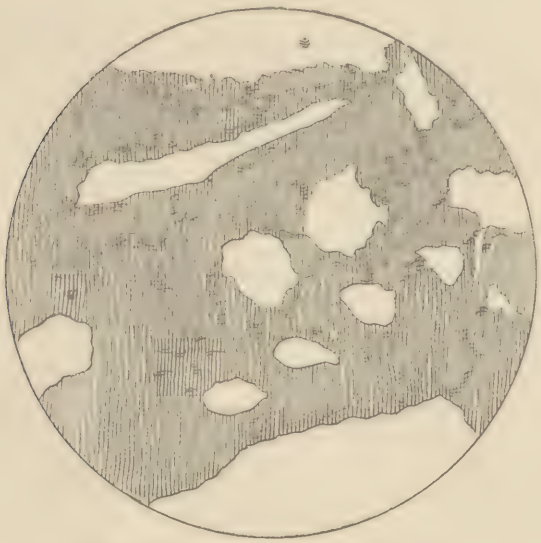
Horizontal section of periosteal outgrowth from phosphorus-necrosis of jaw.

The wood-cuts are copied from photo-micrographs taken with a $\frac{1}{4}$ in. lens; natural size about 50 ×.

the substance of the new formation of bone, as can be seen by the varying angles of obliquity at which the canals are found to be cut in the section. The new substance is rather like a sponge, in which the channels of the largest size are, in general, vertical, as is but natural, since the other channels with which they communicate are seated in the directly subjacent jaw, or the superimposed periosteum.

Compared with other periosteal outgrowths, originating from other causes than phosphorus-necrosis, it will be seen that the same arrangement of canalization holds true as in this specimen. Here, in vertical and horizontal sections from a periosteal outgrowth from a femur (Figs. 7 and 8), the horizontal sections show larger sized

Fig. 7.



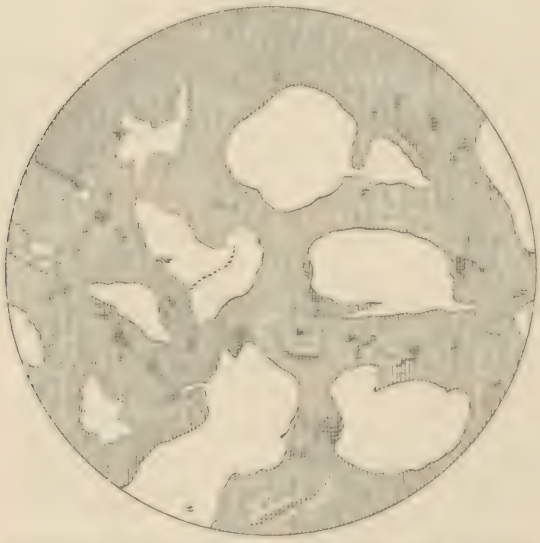
Vertical section from periostitis of femur.

canals than the vertical sections, while the bone-trabeculæ in these two sets of sections (periostitis of femur) have about an equal thickness. The outgrowth from the femur shows about the same macroscopic appearances as that from phosphorus-necrosis, except that the former is much more dense; the latter may be cut with a knife, the former requires a saw for its division.

Compared with normal bone the chief direction of the canalization system is found to be governed by the same principles in the normal, as the pathological, growth. The law is that the canals

pursue the same general course as the blood supply most nearly contiguous to them. On or near the periosteal surface the canalization is more or less vertical, perhaps tending somewhat horizontally, inclined towards the distal extremity in the long bones; in the

Fig. 8.



Horizontal section of an outgrowth from periostitis of the femur.

deeper layers of the compact tissue of the long bones the canals conform in their direction to the long axis of the bone. In flat bones the canals are almost wholly placed vertically in reference to the periosteal blood-supply. In the periosteal outgrowth the canalization system is found, therefore, to conform to the law governing normal tissue.

In respect to the cellular elements, bone-corpuscles, etc., found in this periosteal outgrowth from phosphorus-necrosis, it is impossible to speak, since the specimen is a dried one from which the softer tissues have disappeared.

The lamination which is visible in the specimen, and which is of not uncommon occurrence in periosteal outgrowths, is much more apparent than real. A section made through the junction of two laminæ, very distinct to the naked eye, does not show to microscopic vision any differentiation of tissue, or any disturbance of the arrangement of the canalization system, which is apparently continu-

ous through the two superimposed laminæ. The laminæ are to be regarded as marking the steps of the growth—a temporary cessation of the formation of the periosteal deposit or outgrowth. The new lamina cannot be regarded as a *de facto* commencement of a new process, but merely as a continuation of the old morbid process, with a very short interval or halt.

With regard to the reproduction of bone after phosphorus-necrosis, involving the upper jaw, the cases under my care have confirmed the experience of others who have had opportunities to observe similar cases. In no instance has there been more than a development of fibrous tissue after loss of substance. M. Ollier, of Lyons, records one case of phosphorus-necrosis of the upper jaw, in which a certain amount of new bone was produced. He also quotes a case reported by Billroth, of a similar character. Mr. Heath, in his work on the jaws, states as his opinion that these cases must be regarded as quite exceptional.

The permanent character of the new bone formation has been called into question by Mr. Salter, who states in his article in *Holmes's Surgery*, vol. iv., that the "repair of the lower jaw is but temporary, for after a time, often a considerable time, the new bone diminishes by absorption to a mere arch." He has found this state of the bone in one case in which the lower jaw had been removed ten years, and asks as a question of theoretical interest and of practical importance how far this loss can be prevented by supplying it with a function through the means of artificial teeth. While more or less absorption does undoubtedly occur, it has been my observation that this condition is affected largely by the period of time in the deposit of the new bone at which, and the manner in which, the operation for removal of the sequestrum is performed. If removal of the sequestrum is delayed until well-formed plates of bone have been deposited and care is taken in separating them from the sequestrum to avoid their fracture or dislocation, the absorption which naturally follows will not seriously impair the permanent character of the new-formed bone (Fig. 9). In one case in which I operated in 1881, removing two-thirds of the lower jaw, from the articula-

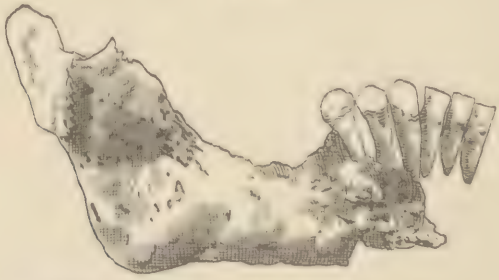
tion on the right side to the first molar on the left, the new bone formation has not exhibited any marked decrease in size up to

Fig. 9.

Appearance of patient after removal of right half of lower jaw—new bone well formed.

this period and the patient has been able to wear with comfort and satisfaction an artificial denture for the past three years. (Fig. 12.)

Fig. 10.

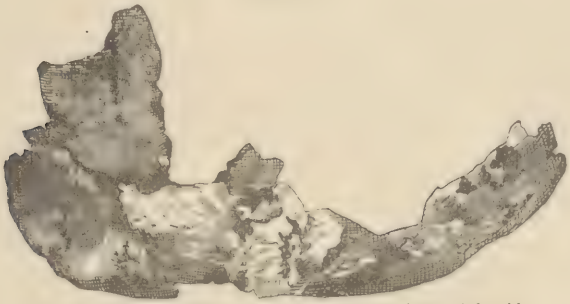


Sequestrum removed from patient shown in Fig. 9.

In another case in which a large portion of the new bone deposit had been removed as a primary operation, and with the intention of interfering in this manner with the progress of the dis-

ease, another layer of bone formed from the periosteal surface, which, however, lacked the density and firmness of the lamellæ

Fig 11.



Sequestrum representing two-thirds of lower jaw—right side.
(From patient shown in Fig. 12.)

Fig. 12.

Appearance of patient with artificial denture after removal of two-thirds of lower jaw—from right side.

deposited originally; as a result a greater degree of deformity occurred in the case than in others in which care was employed

to remove the sequestrum without disturbing to any extent the new bone formation. Whether the adaptation of artificial dentures will in any degree diminish the tendency to absorption is to me a question; it would seem that the pressure exerted and friction produced by the movement of the denture upon the newly formed and rather imperfect bone would develop absorptive action rather than diminish it. Notwithstanding, I always endeavor to have dentures adapted in order to supply the loss so much felt by patients.

With regard to the relative frequency with which the upper and lower jaws are attacked, the cases under my care have shown a decided proportion in favor of the lower jaw. Out of sixteen cases the lower jaw was involved in eleven, and the upper in five; in three both upper and lower jaws were attacked, the upper in a much less degree than the lower. This preponderance in favor of the lower jaw has been observed by the German and other authorities. Of fifty-two cases reported by the former, as stated by Mr. Heath, twenty-one were of the superior maxilla, twenty-five of the inferior, and five in which both were involved. Mr. Salter, *Holmes's Surgery*, vol. iv., records five cases under his care, in four of which the lower jaw was diseased, and the upper in one. In seventeen instances of which he obtained information, nine were connected with the superior and eight with the inferior maxilla. In Agnew's analysis of 111 cases, 58 were of the lower and 41 of the upper, with 12 in which both were involved. From the information I have been able to obtain with regard to cases occurring in this country, the lower maxilla appears to have been attacked more frequently than the upper. These cases show, as in those under my care, that the upper jaw is not, as a rule, involved to the same extent as the lower—the disease being limited rather to the alveolar border. This comparative immunity enjoyed by the superior maxilla is to be explained, it seems to me, by the difference in the configuration, the character of the structure, and the blood supply of the two bones. The presence of the sinus within the body of the superior maxilla lined by a membrane endowed with a good blood supply would enable the bone to resist the advance of the

necrotic action. The absence of a large amount of cancellous tissue as compared with the lower jaw would also favor this immunity, although Mr. Heath is of the opinion that necrosis occurs less frequently in cancellous than in compact bone. Such has not been my observation in connection with necrosis of the lower jaw arising from various causes, since in many instances the dense compact base of the bone seemed as it were to afford a barrier to the advance of the disease.

The *symptoms* of phosphorus-necrosis differ from those of ordinary necrosis mainly in intensity. The pain, which is one of the earliest symptoms, is at first intermittent, but in time becomes continuous. It is also more diffuse from the first, involving the entire bone. The first and second stages are, as a rule, rapidly passed through, and suppurative periostitis manifests itself in the peri-alveolar and peri-dental membranes causing the teeth to become loose and pus to exude from the alveoli. The inflammation quickly extends, involving the structures of

Fig. 13.

Necrosis of left half of lower jaw with sinuses opening at the base.

the gums and detaching them so as to expose the alveolar border. Infiltration of the tissues of the face follows, and swelling, which produces marked deformity, occurs. Soon the in-

flammation invades the entire periosteal layer, and the formation of the laminated bone can be distinguished, and offensive discharges escape into the mouth; in the case of the lower jaw the pus gravitates to the base and escapes by sinuses at this point (Fig. 13) or at some point lower down. In one case under my care the sinus had opened at the upper border of the clavicle before the patient presented herself to me for treatment. In some instances the pain continues during the suppurative action —as a rule, it is much diminished or disappears. When the inflammation involves the condyle of the lower jaw, great pain is experienced in the ear of the affected side, and occlusion of the jaws, which before may have been partial, now becomes complete. The interference with the ingestion of proper food owing to the condition of the mouth, the suffering endured by the patient associated with the constant presence in the mouth and the swallowing of the offensive discharges from the dead bone, all combine to deteriorate in a marked degree the general health of the patient. Unless proper remedial measures are resorted to, death may ensue from exhaustion, or in very severe cases, from gangrene of the overlying soft structures. In rare instances, such as the one alluded to in another part of this paper, the disease may assume a chronic form and the general health may be maintained during a period of years, whilst the sequestrum slowly disintegrates and the debris is carried off through sinuses.

The *treatment* may be divided into that of three stages, primary, intermediate, and secondary. The primary stage may be described as that in which the periosteum, in its morbid condition, manifests the results of beginning irritation. Unless alarmed by the occurrence of necrosis in a fellow workman, the patient rarely presents himself for treatment in this stage. Pain in the bone of a diffused character—intermittent in occurrence, with the sensation of protrusion of the teeth—soreness in the gums, with hemorrhagic transudations during mastication or upon the use of the tooth-pick, are the chief symptoms present in this stage. An examination may reveal one or more of the teeth in a carious condition; around the necks of the diseased, as

well as of the sound teeth, there may be found a collection of tartar extending some distance beneath the gums and displacing the soft tissues, while a softened condition of these structures with a discoloration of a purplish hue may be present. In this stage the treatment relates to the condition of the teeth, which should be conducted with the utmost care in order to avoid the production of periostitis, and the administration of remedies which are antidotal in character. Those teeth which are too much diseased to be saved by treatment should be extracted, especial care being taken to avoid fracture of the tooth or of the process. Collections of tartar should be thoroughly and carefully removed, the instrument being carried well up under the gums to remove any that may be lodged in this position. The carious teeth should receive careful treatment so as to relieve the sensitive condition which exists, and to avoid by gentle manipulation the development of peri-dental inflammation. Temporary fillings should be inserted until such time as it may be prudent to employ those of more permanent character. The soft structures should be bathed with detergent and astringent lotions, as the phenol sodique, alcohol, tincture of myrrh, etc., in dilute solutions.

The constitutional treatment should consist in the administration of anodyne remedies to relieve pain and soothe the general system, and of that agent which is regarded as possessed of the power to neutralize the effects of the poison and arrest the disease. Dr. Letheby, in his work on "Chemistry of the Poisons," recorded his observations upon the power of the vapor of turpentine to neutralize that of phosphorus. Andant, quoted by Bartholow, was the first to report cases in which the antidotal properties of turpentine were observed, and Personne, by experimental demonstration confirmed the observation of Andant. The latter further inferred that "as turpentine destroyed the luminosity in the dark and arrested the escape of the vapor of phosphorus, that it acted similarly as an antidote in preventing the combustion of phosphorus in the blood and the consequent consumption of the oxygen." Höhler and Schimpf (Bartholow) showed by experiment that the commercial oil of turpen-

tine, that which had been exposed for some time to the air, and was, therefore, rich in ozone, was the only variety efficient as an antidote, that this form prevented fatty degeneration of the tissues, and that under its influence no free phosphorus could be found in the animals experimented on.

In the cases which have come under my care, five have presented themselves in the first stage of the disease, and in these I have been enabled to employ the plan of treatment outlined above. In two treated some three years since, the disease was arrested in the primary stage. At present I have three patients under this plan, and in these there are positive evidences of improvement.

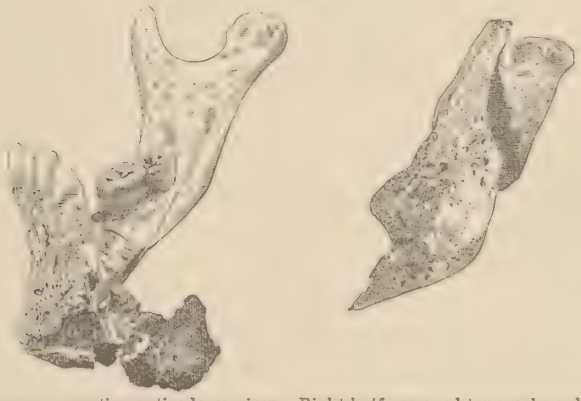
In the stage which I have designated as the intermediate, in which the inflammation of the periosteum is well established, the plan of treatment should be such as to arrest, if possible, the inflammatory action and thus limit the destruction of bone. Active antiphlogistic measures are here indicated, free incisions of the periosteum, the knife being carried to the bone, should be employed, and the use of such internal remedies as will assist in combating the condition of inflammation. According to my experience the efforts to arrest the progress of the disease in this stage are, as a rule, without much avail; the specific character of the inflammation, so far as relates to its cause, and the rapidity with which it becomes general, seem to resist any successful interference. Measures should always be adopted, however, with the hope of at least limiting the subsequent necrosis.

When the inflammation has passed to the suppurative stage and the death of the bone accomplished, the treatment should consist in that which is supportive and expectant. Warm water should be freely used to cleanse the mouth, after which very dilute solutions of carbolic acid, iodine, or permanganate of potassium, should be thrown upon and around the exposed bone with a syringe so as to disinfect the parts and remove the collections of pus. A layer of 7½ per cent. iodoform gauze should be packed around the exposed bone so as to receive the secretions and prevent as far as possible their escape into the mouth and mixture with the food. If sinuses have formed, they

should be cleansed by injections of medicated solutions as advised for the mouth, and a mass of iodoform gauze and cotton should be placed over the openings and held in position by a bandage. Poultices and warm fomentations should not be applied to the face, as they increase the suppurative action and invite the flow of pus to the surface, resulting in the formation of sinuses and consequent disfigurement. Nothing should be done to interfere with the bone reproduction. No efforts at removal of the sequestrum should be made until the necrotic action is completed and the reproduced bone is sufficiently firm to preserve the shape of the original bone. In three of my earlier cases I endeavored to arrest the progress of the disease by cutting away the exposed process and scraping off the periosteum with the layers of new formed bone. In no instance was the operation successful in stopping the disease, and the deformity which followed the subsequent removal of the complete sequestrum was greater than in cases in which this plan of treatment was not attempted.

The sequestrum should be removed through the mouth, care being taken to separate the laminæ of new bone entirely, so

Fig. 14.



Sequestrum representing entire lower jaw. Right half removed ten weeks subsequent to removal of left half.

that they will not be fractured or drawn away with the sequestrum. When the disease has invaded the condyloid and coro-

noid processes of the lower jaw, the disarticulation is easily effected after incision of the structures in front of the ramus. In some instances it may be necessary to divide the ligaments of the articulation with the probe-pointed bistoury. When the entire lower jaw is involved, I have found it desirable in order to preserve the contour of the parts to remove but one-half at a time. After the expiration of eight or ten weeks the remaining portion may be removed. (Figs. 14, 15.)

Fig. 15.

Appearance of patient after removal of the entire lower jaw.

After the removal of the sequestrum the cavity between the two layers of new bone should be cleansed and packed with 7½ per cent. iodoform gauze; at each dressing the quantity used should be lessened in order to permit of the approximation and consolidation of the bone plates. For some time after removal of the sequestrum in the lower jaw a bandage should be applied so as to support the new bone. After removal of the sequestrum in the upper jaw the same form of dressing should be used until the cavity is closed by the fibrous tissue which forms, as a rule, in place of bone.

During the period of suppuration the strength of the patient is to be maintained by the administration of preparations of

iron and quinine, concentrated food and well-regulated exercise in the open air. Care should be taken to avoid exposure to cold, and the hygienic surroundings should be carefully attended to.

The prevention of the disease is to be accomplished by the joint efforts of employers and employés. The introduction into the manufactories of systems of ventilation which will promptly remove the phophorus fumes and as well the smoke from burning matches, will contribute materially to prevent the occurrence of the disease. While this may be accomplished successfully so far as relates to certain parts of the works, there are practical difficulties in the way of securing it in those rooms in which the matches are handled and constantly igniting, owing to the great danger which would arise from serious conflagrations if currents of air sufficient to remove the fumes and smoke were introduced. Efforts should, however, be made until some safe method is devised to accomplish this. In one factory with which I am familiar, exhaust fans have been arranged so as to remove the fumes promptly from over the dipping machines. Since the introduction of this plan the employés working at these machines have been free from disease. Experience has proven the value of turpentine in neutralizing the toxic effects of the phosphorus fumes, and, as in the factories in England and on the continent of Europe, the employés in this country should protect themselves by wearing open, wide-mouthed bottles containing this agent, suspended by straps around the neck so that they should rest upon the anterior surface of the chest, affording, in this way, ready inhalation of the vapor. At various points in these rooms, protected from fire, large shallow vessels containing turpentine should be placed in order that its vapor may come in contact with that of the phosphorus and neutralize it. The substitution of amorphous phosphorus which does not fume, for the common phosphorus in the manufacture of matches has been recommended. The chief objections to its use are the cost, which is stated to be double that of the common phosphorus, and its want of ready fusibility. The safety match which is being gradually introduced into use is stated to contain no phosphorus. The chemically charged paper attached to the boxes is said to contain

amorphous phosphorus, and the manufacture, therefore, of this form of match should be free from danger.

On the part of the employés immunity from danger can be secured by the use of turpentine, as suggested above, frequent inspection of the teeth, and cleanliness. Inspections of the teeth should be made frequently, all accumulations of tartar should be removed, and carious teeth carefully extracted or treated and filled; during the treatment of the teeth or immediately after extractions, the patient should not engage in work in the factory. Careful washing of the hands before taking food should be insisted upon and enforced by those in authority, and if it is necessary that the noon meal should be eaten in the factory, a special room should be provided for this purpose, separate from the work-rooms.

I feel quite confident from the investigations made by me in connection with the cases which have been under my care, that it is possible, by the adoption of proper methods of ventilation in the factories and the enforcement of proper regulations relating to the employment of antidotal agents and strict attention to cleanliness, to prevent the occurrence of the disease. It affords me pleasure to state that the largest manufacturing establishment in this country, The Diamond Match Company, which exercises the most liberal care of the operatives attacked with disease, is keenly alive to the importance of securing, by the adoption of all means available, the prevention of the disease.

I desire, in conclusion, to submit the following propositions:—

1. That the disease is a local expression of the constitutional condition produced by the inhalation of the vapor of phosphorus, and by particles of the agent taken into the system with the food by operatives in match factories who do not give proper attention to cleanliness of the hands.

2. That the introduction of the agent into the system is, as a rule, very gradual, and in such small quantities as to avoid the production of symptoms of acute poisoning; that, in this way, the chronic toxic condition of the system is induced, characterized chiefly by disintegration of the red-blood corpuscles and fatty degeneration of the arterial coats.

3. That the toxic condition precedes the jaw disease, as is shown by the fact that the disease does not attack operatives recently exposed to the action of the agent, but those who have been exposed for a period of years.

4. That examination of the teeth of operatives has shown that many who have caries, and have returned to work immediately after the extraction of teeth, have enjoyed immunity from the disease, showing that the agent had not attacked the periosteal tissue thus exposed. This was further shown by the fact that in one of the cases necrosis did not appear until three months after labor in the factory had ceased.

5. That individuals vary in their susceptibility to the action of the poison; for this reason many suffer immediately with acute symptoms, such as nausea, vomiting, etc., and are compelled to abandon work in the factories.

6. That the conditions under which experiments have been made on animals, to prove the absence of the disease until exposure of the periosteum and peri-alveolar tissue was effected, are not similar to those to which operatives in match factories are subjected.

7. That treatment of the disease in the primary stage is efficient and prevents its progress.

8. That the antidotal powers of turpentine have been established.

9. That the disease is to be prevented among operatives by the adoption of thorough methods of ventilation, stringent rules with regard to cleanliness, and the free disengagement of the vapor of turpentine in all the apartments of factories in which the fumes of phosphorus escape.